ISSN 0838-1992

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Proceedings, 6th IWRA World Congress
on Water Resources, 29 May - 3 June 1988
Ottawa, Ontario, 255-262, 1988

NHRI Contribution No.88003

1988

90-06494/

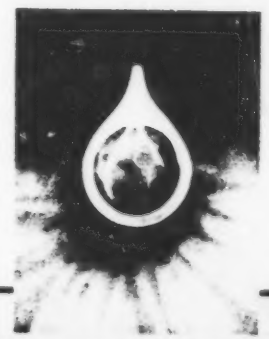
Water for World Development

Proceedings of the VIth IWRA World Congress on Water Resources

May 29-June 3, 1988
Ottawa, Canada

Volume III

Agriculture, Irrigation, and Drainage; Environment



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88003

Herbicide, Nutrient, and Water Balance from an Irrigated Field*

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ABSTRACT

Based on a one year study, irrigating a soft, white, spring wheat (Triticum aestivum) by the corrugation method has resulted in 14.3% of the applied irrigation water being returned as surface drainage water.

With respect to applied nutrients, 0.1% (0.12 kg/ha) of the applied nitrogen and 0.12% (0.07 kg/ha) of the applied phosphorus was lost to surface drainage water. Maximum concentration of nutrients observed was 0.54 mg/L for total ammonia, 0.74 mg/L for dissolved nitrite + nitrate, 0.26 mg/L for ortho-phosphorus, and 0.40 mg/L for total phosphorus.

With respect to applied herbicides, maximum concentrations of 4.3 ug/L Dicamba and 10.7 ug/L MCPA were observed. The total loss of herbicides to drain water was 0.13% (0.13 g/ha) of Dicamba and 0.11 % (0.44 g/ha) of MCPA. The levels of concentration are below the LC_{50} limits of 10 ug/L for aquatic invertebrates (USEPA 1983).

The highest concentration of nutrients and herbicides was found in the first flush of surface drain water from the first irrigation as opposed to the second irrigation. This suggests the reuse of drain water from the first irrigation should be avoided in order to minimize the risk of damage to sensitive crops.

INTRODUCTION

The full impact of irrigation development on the Canadian Prairies has not been fully assessed. The efficiency of irrigation conveyance systems has been studied in Southern Alberta (Manz 1984). Irrigation efficiencies of irrigation districts in southern Alberta have been summarized (Heywood 1978). However, none of these studies addresses

* National Hydrology Research Institute Contribution No. 8803

the question of both the quantity and quality of drainage water that can be expected from surface irrigation.

In the United States, the International Joint Commission review of the Garrison Diversion Project for irrigation in North Dakota (International Joint Commision Garrison Diversion Study Board Report 1976) recommended a 5000 acre field study to assess the impact of irrigation. Although the study was initated, (U.S. Dept. of the Interior, 1980), progress was halted as a result of a U.S. Presidential Commission Review.

With the growing interest in expanding irrigation in Canada, the use of irrigation return flows is being explored. These can improve overall irrigation efficiency and reduce the unit costs of irrigation development. However, it is necessary to determine if this practice is environmentally sound. In addition, with increased costs in irrigation farming, the efficiency of the application of irrigation water, nutrients and herbicides must be examined. If efficiencies are not high, alternative management techniques such as fertigation may be considered. Finally, the impact of irrigation return flows on receiving waters should be evaluated. To this end, a study supported by the Saskatchewan Agriculture Development Fund was initiated in 1986 to examine the herbicide, nutrient and drainage water from a field irrigated by the gravity corrugation method. The objectives of the study were to determine:

1. The amount of surface drainage water following each rainfall and irrigation event;
2. The quality of surface drainage water with respect to nutrients and herbicides;
3. Irrigation efficiency with respect to application of irrigation water, nutrients and herbicides;
4. The impact of irrigation drainage and downstream flows on water quality.

This paper will report the results of the 1986 study.

SITE SELECTION

In consultation with staff of the Irrigation Branch, Saskatchewan Agriculture, a site was selected that met the following requirements:

1. Irrigation inflow and drainage outflow could be easily monitored.
2. The crop grown by the producer was "representative" of some of the crops grown in the irrigation area.
3. The inputs to the crop grown included the use of herbicides and pesticides.
4. The owner of the field site was a willing co-operator who allowed access to the field site to collect soil and water samples, and provided information as to the farming practices and inputs utilized, etc.

The site selected for the 1986 field season that met the criteria was located on the farm of Roger Pederson N.E.1/4, SEC. 17, TWP. 28, RGE 7, W.3rd.

Details of the study area, land treatment, etc. are as follows:

1. 16.7 hectares irrigated by the corrugation method.
2. Prior to seeding, the area was fertilized with anhydrous ammonia at a rate of 107 kg/ha of total nitrogen.
3. At the time of seeding with soft white spring wheat (Triticum aestivum), fertilizer was applied at the following rate:
   11.2 kg/ha nitrogen
   56.1 kg/ha phosphorous
   22.5 kg/ha potassium
4. The crop was sprayed with Dyvel(400 g MCPA and 100 g Dicamba) active ingredient per hectare.

INSTRUMENTATION and DATA COLLECTION

Inflow (applied irrigation water and outflow)

The inflow was determined by measuring the pumping rate with a doppler flow meter. Runoff was measured using a V-shape (one to two) sharp-crested weir and a Stevens A-35 recorder. The runoff rate was calculated from the head measured by the recorder. A specially designed programmable sampler (SRC sampler) was used to collect water samples for herbicide analysis without contamination.

Rainfall

Rainfall was measured with a totallizing tipping-bucket raingauge.

Water Samples

Background water samples were taken from the supply of irrigation water as it left the pipe. A minimum of two samples were taken for each section of the irrigated field. Runoff samples were taken every hour with the SRC water sampler at the weir site.

Water analysis

Water samples were analyzed for nutrients (total phosphorous, ortho-phosphorous, total dissolved nitrates and nitrites, total ammonia, electrical conductivity) by the Water Quality Laboratory of Environment Canada according to standard procedures outlined by Traversy (1971).

For analysis of Dicamba/MCPA in water the methodology utilized was as follows:

- Take 500 ml of unfiltered water sample and place in 1000 ml separatory funnel.
- Adjust pH to less than 2.0
- Add 80 grams of NaCl and shake.

- Extract the acid forms of Dicamba/MCPA by shaking with 2 x 100 ml portions of diethyl ether.
- Run each diether extract through a funnel containing 25 gms of anhydrous Na2So4 and into a 500 ml flat bottom boiling flask.
- Rinse the funnel with an additional 10 ml diethyl ether.
- Evaporate the diethyl ether to dryness on a rotary evaporator at 40°C.
- Azeotrap any water remaining by adding 20 ml acetone, placing on the evaporator and taking to dryness.
- Transfer the residue from the 500 ml boiling flask, into a 50 ml graduated centrifuge tube using 5 x 2 ml portions of diethyl ether.
- Evaporate the diether to approximately 1.0 ml on the N2 evaporator.
- Sample is now ready for methylation.
- Methylate by adding 2 ml of diazomethane to the centrifuge tube, and allow to stand for 15 minutes.
- Transfer the methyl ester of Dicamba/MCPA from the diethyl ether into hexane by adding 2 x 2 ml portions of hexane, placing on the N_2 evaporator and concentrating down to 1.0 ml.
- Sample is now ready for column clean-up.

Column Clean-up

- Wet pack a 7 mm I.D. chromatograph column with 4 ml of 5% deactivated forisil 60/80 mesh.
- Prewash the column with 10 ml hexane.
- Add the sample to be cleaned-up to 1.0 ml hexane.
- Dilute the column with 30 ml of 0.5% acetone in hexane, while collecting the 10 to 30 ml fraction containing the methyl esters of Dicamba/MCPA
- Concentrate the elute to less than 1.0 ml.
- Bring to final volume of 1.0 ml in volumetric flask.
- Ready for GLC analysis.

Gas Chromatograph Conditions

- Gas Chromatograph: Tracor 560 equipped with a Hall 700 A detector, operated in a Cl mode.
- Column: Ultra Bond 4 mm I.D. x 1.8 m.
- Temperatures: Column: 170°C isothermal
  Injector: 220°C
  Furnace Base: 250°C
  Furnace: 810°C
- Gas Flows: Column: 25 ml/min Helium (UHP)
  Reaction gas: 20 ml/min Hydrogen (UHP)
- Solvent Flow: 0.7 ml/min N-propanol
- Integration: Varian Vista 401 Data System
- Injection: Varian 8000 autosampler, on column

Irrigation Efficiency (with respect to surface drainage water only):

The amount of surface drainage water expressed as percentage of applied irrigation water for each irrigation and for the season's irrigation is presented in Table 1.

Table 1. Amount and % surface drainage water for each irrigation.

	Total Acc. Inflow (M3)	Total Acc. Run-off (M3)	% Drained
1st irrigation	16,615	2,135	13
2nd irrigation	11,424	1,864	16
	Total % Drained		14.3

Assuming deep percolation was minimal, the irrigation efficiency of the border dyke system in this study was in the order of 85% compared to the average of 70% reported in Alberta (Monaghan and Pungor, 1985).

Nutrient loss

The range of concentrations of nutrients found in both supply water and drain water are noted in Table 2.

Table 2. Nutrient concentrations found in supply and surface drainage water.

	Supply Water		Drain Water	
	min	max	min	max
	mg/L			
Total Phosphorus	0.015	0.027	0.10	0.40
Ortho-phosphorus	0.003	0.003	0.003	0.26
Dissolved NO2+NO3	0.04	0.06	0.05	0.74
Total Ammonia	0.05	0.07	0.09	0.54

The maximum phosphorus levels observed in the water are in excess of the maximum acceptable level of 0.1 mg/L recommended for domestic consumption (McNeety et al.1979). The weighted mean concentration of 0.29 mg/L is higher than the acceptable level.

The loss of applied nutrients as determined by analysis of drainage water is presented in Table 3 . Noted is the loss of applied nutrients expressed as kg/ha and % of the amount applied.

Table 3. Nutrient loss in surface drainage water expressed as a percentage of the amount of applied fertilizer.

Nutrient	Applied	Loss (1st.) (Irr.)	Loss (2nd) (Irr.)	Total Loss	%
	kg/ha				
Nitrogen	118.2	0.09	0.03	0.12	0.1
Phosphorous	56.1	0.04	0.0	0.07	0.12

The total amount of nutrient loss expressed as a percentage of applied fertilizer was found to be very low. The levels were found to be comparably less than from a non-irrigated stubble and unfertilized summerfallow field (Nicholaichuk and Read, 1978).

Herbicide Loss:

The range of concentrations of herbicides found in both the irrigation water and the drain water are noted in Table 4. The levels of MCPA and Dicamba are within the LC_{50} limitsof for aquatic invertebrates (U.S.E.P.A. Factsheet, 1983). It must be recognized that these chemicals degrade by as much as 50% in a two week period.

Table 4. Herbicide concentrations found in irrigation and surface drainage water.

	Irrigation Water min	Irrigation Water max	Drain Water min	Drain Water max
	ug/l			
Dicamba	0.01	0.027	0.01	4.27
MCPA	0.003	0.003	0.02	10.7

The loss of applied herbicides as determined by analysis of drainage water is presented in Table 5. Noted is the loss of applied herbicides expressed as g/ha and % of the amount applied.

Table 5. Herbicide loss in surface drainage water expressed as a percentage of the amount of applied.

Herbicide	Applied	Loss (1st.) (Irr.)	Loss (2nd) (Irr.)	Total Loss	Loss %
	g/ha				
DICAMBA	100.0	0.11	0.02	0.13	0.13
MCPA	400.0	0.42	0.02	0.44	0.11

Based on the surface drainage discharge and hourly observations of concentrations of MCPA and Dicamba, most of the loss occurred during the first irrigation. However, the amount of loss is a very small percentage of the amount applied. The 0.11% loss of Dicamba was far less than 3.3% loss observed in a simulated 'catastrophic' rainfall event observed by Wauchope(1978).

Loss of both nutrients and herbicides is a function of agronomic practices. Suitable land use practices such as minimum tillage and crop rotations that minimize erosion and runoff losses will result in minimal environmental contamination through the use of chemical fertilizers and herbicides.

SUMMARY

Irrigating a soft white spring wheat crop in the South Saskatchewan Irrigation District in the 1986 crop season using the corrugation method resulted in the following:

1. 2.4 cm or 14.3% of the applied irrigation water is returned as surface drainage water.

2. 0.12 kg/ha or 0.1 % of the applied nitrogen, 0.07kg/ha or 0.12% of the applied phosphorous was lost to surface drainage.

3. Maximum concentrations of nutrients were observed as follows:
   - 0.40 mg/L total phosphorous
   - 0.26 mg/L ortho-phosphorous
   - 0.74 mg/L dissolved nitrite + nitrate
   - 0.54 mg/L total nitrogen

- 2.11g or 0.13% of the applied Dicamba and 7.3g or 0.11% of the applied MCPA was observed in the surface drain water from the first irrigation.

Preliminary data suggests that herbicide losses occur primarily during the first irrigation. As a result, if drain water is to be reused for subsequent irrigations, it may be necessary to avoid using the surface drain water that occurs after the first irrigation.

ACKNOWLEDGMENTS

The authors of this report would like to acknowledge the financial support received from the Agricultural Development Fund for this study. The co-operation of Roger Pederson, owner of the land on which the study was conducted, made this study possible. In addition, the assistance of Garth Weiterman of the Irrigation Branch of Saskatchewan Agriculture and Brian Ireland of Saskatchewan Water Corporation is also appreciated. The technical support of Lorne Kerr of Agriculture Canada, Nick Nicolichuk of the Saskatchewan Research Council, Kelly Best and Keith Wallace of the National Hydrology Research Institute is also gratefully acknowledged.

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